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SCENARIO AGENT: A RULE-BASED MODEL OF POLITICAL BEHAVIOR FOR US--ETC(U)
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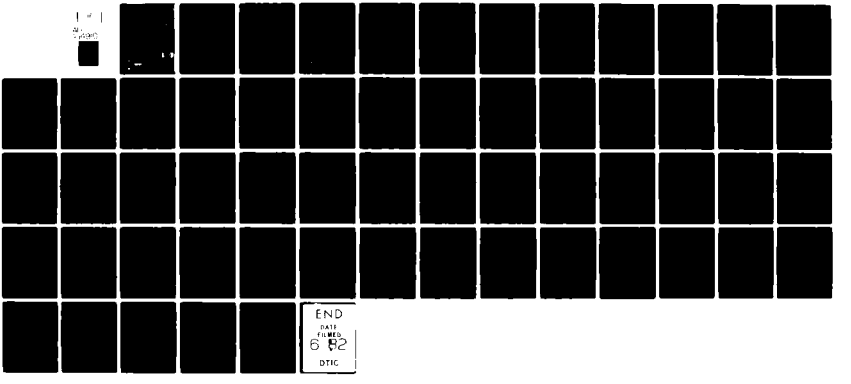

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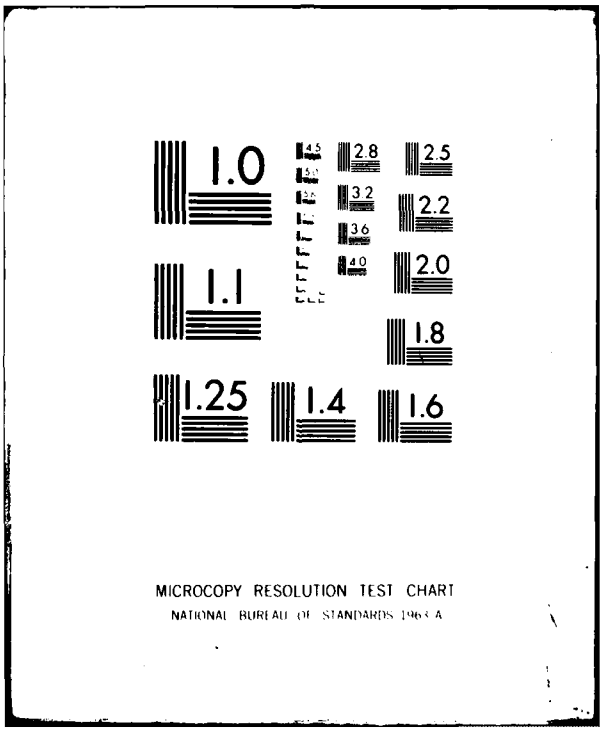
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This Note describes a first-generation experimental computer model, Scenario Agent, as developed in Rand's Strategic Assessment Center in early 1981. Section II describes the Strategic Assessment Center and the role the Scenario Agent plays in it. Section III describes the conceptual approach taken in developing the Scenario Agent. Section IV discusses the Scenario Agent's inner workings in some detail so both programmers and non-programmers can understand them. Section V illustrates the results of using the Scenario Agent in a demonstration of the Strategic Assessment Center and discusses ideas of future refinement, some of which are now being implemented. Four appendixes list names of scenario entities, give examples of tabular scenario (tableau) and of a narrative scenario, and discuss rule-based modeling.

A RAND NOTE

SCENARIO AGENT: A RULE-BASED MODEL OF POLITICAL BEHAVIOR FOR USE IN STRATEGIC ANALYSIS

James A. Dewar, William Schwabe,
Thomas L. McNaugher

January 1982

N-1781-DNA

Prepared For

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Rand
SANTA MONICA, CA. 90406

PREFACE

This Note describes a first-generation experimental computer model, Scenario Agent, as developed in Rand's Strategic Assessment Center in early 1981. The work was sponsored by the Director of Net Assessment, Office of the Secretary of Defense, and by the Defense Nuclear Agency (DNA) under DNA contract 001-80-C-0298. Although the Note is intended for a general audience, it should be of special interest to those concerned with political-military analysis and with nuclear and conventional strategic analysis. Inquiries and comments are welcome; they may be made directly to the authors or to Paul K. Davis, Director of the Rand Strategic Assessment Center.

ROSIE, the computer language referred to in this Note, is a trademark of The Rand Corporation.

SUMMARY

Rand's Strategic Assessment Center (RSAC) is investigating a largely automated system of wargaming intended to combine much of the richness of traditional wargaming with the replicability and rigor of analytic modeling. One part of the system is an experimental computer model called the Scenario Agent. It is designed to simulate responses of countries other than the United States and the Soviet Union to hypothetical conflict situations that may involve the superpowers. It communicates responses to other computerized Agents or to teams of human players that are simulating superpower behavior.

Most strategic analysis focuses on superpower behavior or capabilities. Any actions other countries are hypothesized as taking are generally considered part of the scenario. That is one reason the RSAC non-superpower simulation model is called a Scenario Agent.

There is, however, a more profound reason for the name. Scenario Agents are important to many strategic analyses because they embody speculation or belief, which cannot be quantified or empirically proven but is needed to provide the context for analysis. The qualitative aspects of scenarios do not, however, justify lack of rigor in scenario writing. Increased rigor in scenario writing is a long-term goal of Scenario Agent development.

A fully developed Scenario Agent would embody expert speculation and belief, not just in the form of written scenarios, but in the form of rules for writing scenarios. Alternative scenarios for comparative analysis would be produced by alternative scenario-writing rules and

initial situations. The goal in writing scenarios "by the rules" is to make underlying assumptions more explicit, to make scenarios more amenable to controlled variation, and to make scenario-based analysis more replicable.

The fully developed Scenario Agent does not yet exist. The experimental Agent includes the following:

- A set of primitive components from which it is possible to develop highly simplified scenarios dealing with non-superpower entities; these components describe political entities, the military situation, and messages to superpowers.
- A set of rudimentary rules for writing simple, reasonably coherent scenarios; these rules are written in an English-like computer language that can be understood by people who aren't programmers.
- An operating system that interacts with scenario analysts to apply the scenario writing rules and communicates with other computerized Agents.

The first phase of research was completed early in 1981. In the second phase, the Scenario Agent will be used in a stategic analysis of a force structure issue. The Scenario Agent's rule base will be improved as needed to support that analysis, including development of more nation-specific rules, explicit recognition of superpower intentions, better treatment of uncertainties, and incorporation of more subtlety into the rules. Alternative Scenario Agent designs will be considered, but not implemented. Phase II will be completed in 1982.

ACKNOWLEDGMENTS

The authors wish to acknowledge the following Rand colleagues. The entity and situation descriptors used in the Scenario Agent model were developed by William Jones. Additional concepts of formalizing scenario development originated with Carl Builder.

Dan Gorlin, a principal developer of the ROSIE language, answered a great many questions from the authors regarding the use of that instrument.

Lewis Jamison, Paul Davis, and Milt Weiner offered many comments that helped improve this Note.

This Note was edited by Helen Turin.

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I. INTRODUCTION

This Note describes the results of work done at The Rand Corporation through early 1981 in developing an experimental first-generation Scenario Agent for Rand's Strategic Assessment Center (RSAC). The Scenario Agent simulates the actions of nations and groups--other than the United States and the Soviet Union--in hypothetical situations of interest to strategic analysts. It differs from most computer simulation models in that the actions are scheduled in accordance with programmed rules that non-programmers can read and understand. We made this possible by programming the model in ROSIE, an English-like artificial intelligence language developed at Rand.[1]

Section II describes the Strategic Assessment Center and the role the Scenario Agent plays in it. Readers familiar with the Strategic Assessment Center can proceed directly to Sec. III, which describes the conceptual approach taken in developing the Scenario Agent. Section IV describes the Scenario Agent's inner workings in some detail so both programmers and non-programmers can understand them. Section V describes the results of using the Scenario Agent in a demonstration of the Strategic Assessment Center in January 1981 and discusses ideas for future refinement, some of which are now being implemented. Appendix A lists country names as they appear in the Scenario Agent data base. Appendix B is an example of tabular output from the Agent. Appendix C contains a computer-produced narrative report based on the same data that were used to prepare Appendix B. Appendix D has a short discussion

[1] ROSIE is a trademark of The Rand Corporation.

of rule-based modeling, including some artificial intelligence capabilities that might be useful in future generations of the Scenario Agent.

II. OVERVIEW OF THE RAND STRATEGIC ASSESSMENT CENTER

In November 1979, the Department of Defense solicited proposals for development of improved methods for strategic analysis. The objective was to develop an analytic capability that could be transferred to the government for use by a variety of agencies with diverse interests and purposes.

Rand's response proposed development of a system built around an automated political-military game.[1] This automated gaming system would retain the structure of a political-military game but would provide the ability to replace the free-play teams with programmed "agents." Such a structure would retain much of the rich contextual complexity of gaming but, by replacing the humans with explicit programs, would also yield much of the replicability and rigor of analytic modeling.

In its simplest form the classical political-military game involves a Blue team, a Red team, and a Control team. The Blue team typically plays the role of the national level decisionmakers of the United States, and the Red team plays a comparable role for the USSR. The Control team is responsible for everything else required to meet the objectives of the game.

Under the Rand Strategic Assessement Center concept, Control is divided as shown in Fig. 1. This conceptual approach made the control functions more tractable for automation and provided additional operational flexibility by permitting separate aspects of the control func-

[1] For a more complete description of the initial system see Graubard and Builder (1980).

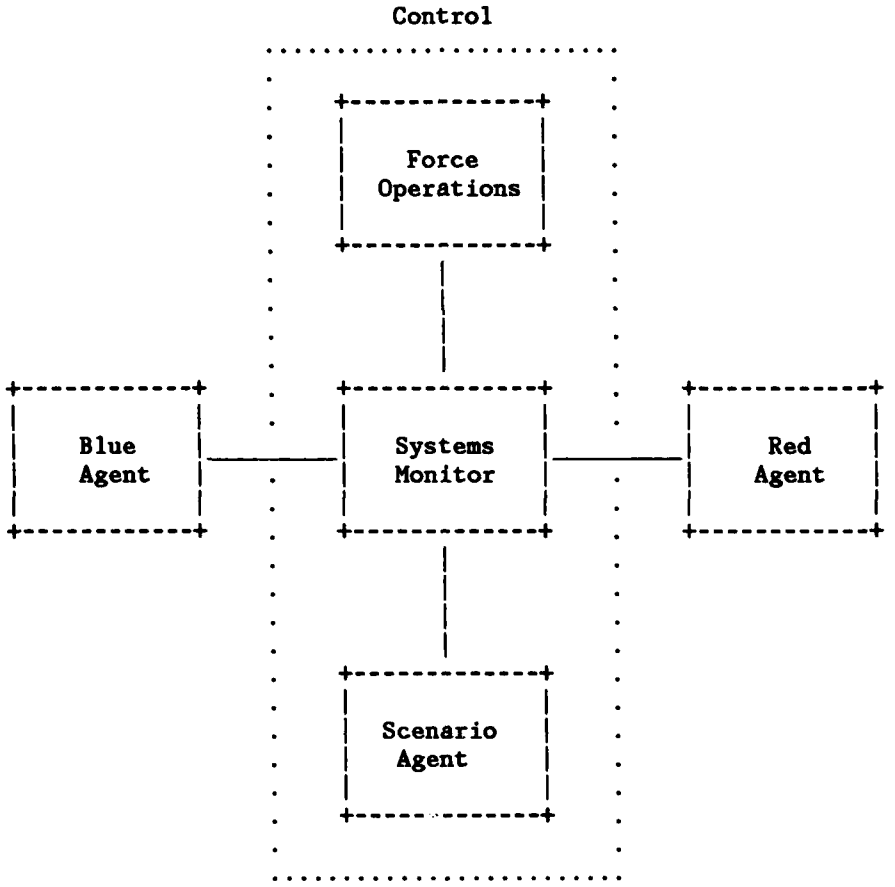

Fig. 1--Rand Strategic Assessment Center structure

tion to be manually or automatically controlled. The Force Operations Agent is responsible for force bookkeeping and for planning and execution of military operations world wide. The Scenario is responsible for all political information and for actions as required to portray the worldwide political situation to the adversaries. The Systems Monitor retains the traditional Control team functions of coordinating the game communications and keeping the game clock and records.

There are two ways to view what Scenario does. First, Scenario can be viewed as a simulation model of all countries other than the United States and Soviet Union. Second, Scenario can be viewed as a set of rules by which scenarios are developed for use in strategic analysis. The two views are, for most purposes, equivalent. The first view emphasizes the nature of the static picture that Scenario provides of the "rest of the world" at each game step. The second view emphasizes the role of the rules that govern the transitions in the static picture from game step to game step. It also emphasizes the evolving scenario as the contextual backdrop for analysis.

Having divided the traditional Control team functions, we had to take some care with the move processing. In a traditional political-military game the adversaries move either simultaneously or sequentially. We chose a modified sequential mode. After each adversary move the following moves take place: Systems Monitor advances the game time and game step, then Force Operations updates the military situation, then Scenario updates the political situation. This procedure efficiently sequences the control functions and allows recording of exercise events step by step for subsequent analysis.

The development of the RSAC is proceeding in phases. Phase I is complete, and Phase II is now in progress. Phase I built and demonstrated a rudimentary system to explore the concept's usefulness. Phase II includes a survey of strategic issues that could be analyzed with the RSAC, exemplary analysis of one or more such issues, and further development of the Red Agent. The Scenario Agent will be developed, as needed, to support other Phase II objectives.

It was unnecessary in Phase I to automate the entire system. Instead, resources were concentrated on automating the Red Agent. The Blue Agent was free-played by a human team. Force Operations used a general purpose force model already in place at Rand and augmented that model with human analysts. Systems Monitor used an automated message system under human control.

III. SCENARIO AGENT DESIGN GOALS

The major goal of the Phase I effort on the Scenario was to automate the Scenario functions in ROSIE. ROSIE is a computer language for programming so-called expert systems. The artificial intelligence (AI) community has become interested in such systems because of their ability to support knowledge bases and heuristic rules of inference. ROSIE was developed at Rand to support a wide range of expert system applications.[1] The Phase I Scenario was one of its first applications.

Why expert systems and ROSIE? One of the major goals of the RSAC is to capture expert knowledge in transparent and repeatable form. Expert systems are intended to do just that. In addition, ROSIE is an English-like language, which gives the expert (and other non-programmers) access to the captured knowledge for verification and revision. If the Scenario functions could be programmed in ROSIE, the effort and the resultant program would provide detailed insight into the utility of an exciting AI concept for the RSAC. Although this was a high-risk approach to the Scenario, there was a low-risk backup approach--have a human team perform the Scenario Agent functions for the demonstration.

Another way of stating the major purpose of the Phase I Scenario is to say it was an experiment in the AI area of expert systems. With that as the overall goal, Phase I subgoals can be grouped into two categories--analytic goals and systemic goals, as shown in Table 1. The

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[1] ROSIE is an acronym for Rule Oriented System for Implementing Expertise. For further information on ROSIE the reader is referred to Fain et al. (1981) and Hayes-Roth et al. (1981).

Table 1

ANALYTIC GOALS AND SYSTEMIC GOALS

Analytic Design Goals
Simulate nation and factional behavior over a broad range of conflict situations
Maintain information on any number of nations and sub-national factions that may be required for strategic assessment
Provide means for entities to communicate with Red and Blue by message
Maintain separate information reflecting Red and Blue perceptions
Record all simulated actions for subsequent analysis
Systemic Design Goals
Provide summary descriptions of the world situation to Red and Blue
Provide a trace of causes of actions
Be able to replay and branch from any game point
Display data base selectively, on demand, on-line
Record all information displayed to operator and all operator actions
Achieve 3-5 minute turn-around time for critical processing

analytic goals relate more to Scenario's role in the political-military game in general and speak more to the political scientist, while the systemic goals relate more to the structure and characteristics of the automated program itself and speak to the computer scientist.

The basic analytic design goal was to automate a Scenario Agent that would simulate some aspects of international behavior over a broad range of conflict situations.

The Scenario Agent had to be able to deal with 100 or more nations or sub-national factions. Although no given conflict is likely to involve 100 nations directly, an escalating sequence of events might include that many over the entire course of events.

The automated actors needed the ability to communicate with one another. Since the two-player game emphasizes the Red/Blue interaction, the Scenario nations could decide only if they would allow their forces to be controlled by Red or Blue and could not initiate military actions on their own. Future systems may relax this constraint.

Scenario was required to provide (as an option) separate Red, Blue, and "real" perceptions of the simulated situation by delaying Red and Blue perception of "real" changes. Length of delays was a variable function of then-current Red and Blue intelligence capabilities and of the type of change.

Scenario was required to catalog all its actions for subsequent analysis.

The reason for Scenario's being an agent is to provide Red and Blue with a status report on the "rest of the world" in an appropriate format. For the January 1981 demonstration the format was important because Red was automated and Blue was a human team.

We automated Scenario to make Scenario nations' actions transparent and repeatable. In terms of design goals these imply the ability to trace the causes of Scenario nations' actions and to replay and branch from any point of an RSAC exercise.

In order to facilitate working with the agent, we required that it display any information in the data base on demand, that it display and

modify its rules easily, that its rules be easy to override, and that it display for the operator every rule executed.

For archiving and post-exercise analysis the agent was required to record all operator actions and CRT displays.

Finally, to support rapid turnaround the agent was required to complete a move's time-critical processing (that processing required before the next agent in sequence could begin its processing) in three to five minutes.

Although the Scenario Agent design and implementation are most precisely reflected in the program listings, the English-like nature of the ROSIE language makes several aspects of the design accessible and interesting to the general reader.

IV. DESCRIPTION OF THE SCENARIO AGENT

The following is a design description, which takes advantage of the English-like nature of the ROSIE language to explain the design in some detail for military analysts, rather than a design specification, which would be of interest only to computer scientists. We first discuss the conventions that describe the situation and then describe the process that transforms one situation to the next.[1]

CONVENTIONS FOR DESCRIBING SCENARIO SITUATIONS

The work we are describing was an initial attempt at structuring scenario situations for rule-based computer processing. Information had to be structured so it could be used by several computer programs (Red, Force Operations, Scenario, and Systems Monitor), operating on three different computers. That required Scenario Agent to be able to process information about entities (nations and factions), the military situation, and messages.

Entities and Terms Used To Describe Them

The Red Agent needed to know the parties involved in conflict and the locations of conflict. Red required that this information be expressed in terms of the current political-military status of the parties and locations rather than in terms of individual country names. Scenario Agent simulates the behavior of individual political-military

[1] In computer terms this division corresponds roughly to (1) the program's data base and (2) its input/output and processing.

entities (nations and armed factions) and keeps track of the current status of each. When preparing output for Red, Scenario Agent collects information about entities by political-military status type. Suppose the FRG is a Blue NATO coordinate combatant[2] that has been invaded by Czechoslovakia and the GDR, each of which is a Red WP (Warsaw Pact) coordinate combatant. This is stored as:

```
FRG
  FRG is an ENTITY
  FRG is blue
  FRG is nato
  FRG is a COORDINATE
  FRG is a COMBATANT
  FRG is a LOCATION of CONFLICT

CZECHOSLOVAKIA
  CZECHOSLOVAKIA is an ENTITY
  CZECHOSLOVAKIA is red
  CZECHOSLOVAKIA is wp
  CZECHOSLOVAKIA is a COORDINATE
  CZECHOSLOVAKIA is a COMBATANT

GDR
  GDR is an ENTITY
  GDR is red
  GDR is wp
  GDR is a COORDINATE
  GDR is a COMBATANT
```

Red cannot process the information in that form, so it is collected by status type and is provided to Red as:

```
PARTIES INVOLVED:

  Blue NATO COORDINATE
  Red WP COORDINATES

LOCATIONS OF CONFLICT:

  Blue NATO COORDINATE
```

[2] A "Blue NATO coordinate combatant" is a NATO member that is a combatant and is receiving arms, combat supplies, and other technical assistance from the United States. These and other terms are defined in Table 2.

The terms used by Scenario Agent to describe entities are listed and defined in Table 2. The choice of terms was guided by the following principles: First, the number of terms should be small but reasonably complete in terms of analytic utility; second, words with ideological or doctrinal connotations were to be avoided; and third, the terms chosen should fit as comfortably as possible into the ROSIE language syntax. We selected terms that suited the needs of the RSAC automated agents. Some observers, however, found certain combinations of terms, such as "cobelligerent noncombatant," confusing. The terms may therefore undergo further refinement.

Scenario Agent uses these terms in ROSIE sentences. ROSIE treats the political status, military status, and conflict location terms (the terms above the horizontal line in Table 2) as nouns. For example, in the phrase "France is a noncombatant" the object "noncombatant" is recognized by the ROSIE language parser program as a noun because it follows "is a." ROSIE treats the remaining terms (those below the horizontal line in Table 2) as adjectives. In the phrase "Poland is red" the predicate "red" is recognized syntactically as an adjective, because it follows "is," not "is a." ROSIE syntax conventions permit adjectives to follow one another in a sentence, as in "GDR is firm red," where each of "firm" and "red" are recognized as adjectives. ROSIE does not allow nouns to follow one another immediately. This allows ROSIE to parse "GDR is a firm red combatant" correctly, with "firm" and "red" treated as adjectives, but "combatant" treated as a noun. Note that the Scenario Agent semantic conventions treat "cobelligerent" as a noun,

Table 2

TERMS USED TO DESCRIBE SCENARIO ENTITIES[a]

Type	Term	Definition of Term
Political Status	belligerent	A superpower having combat objectives in a conflict.
	cobelligerent	A non-superpower entity aiding the combat objectives of a superpower. Receiving arms, combat supplies, and other technical assistance from a superpower. Granting a superpower transit and basing rights, including the right to launch attacks against its enemies from cobelligerent territory. If a combatant, coordinating its force operations with a superpower.
	coordinate	A non-superpower entity receiving arms, combat supplies, and other technical assistance from a superpower. Granting a superpower en route transit and basing rights, exclusive of rights to launch attacks from coordinate territory.
	noncoordinate	An entity not sharing either superpower's combat objectives and not cooperating with either.
	faction	A political entity other than a nation.
Military Status	combatant	An entity engaged in combat.
	combatant on call	An entity not engaged in combat but committed to entering combat with its forces under operational coordination of a superpower if called. Mobilizing if not already mobilized.
	noncombatant	An entity not having forces engaged in combat.
Conflict Location	location of conflict	An entity or locale having combat operations conducted in or against its territory.
Color	red	Soviet Union or its allies.

	white	Not aligned with red or blue.
	blue	United States or its allies.
Alliance	nato	Member of NATO.
	wp	Member of Warsaw Pact.
Resolve	firm	Strongly committed to its position and not likely to make a major change.
	moderate	Might possibly change its position to suit future conditions.
	soft	Likely to change its position in the future.
Tripwire	r-tripwired	Having Soviet combat capable forces deployed on bases in its territory; a hostile attack on that territory would involve those Soviet forces and, therefore, the Soviet Union in the conflict.
	b-tripwired	Having U.S. combat capable forces deployed on bases in its territory; a hostile attack on that territory would involve those U.S. forces and, therefore, the United States in the conflict.
Conflict Arena	local	Local (as opposed to theaterwide).
	theater	Theaterwide.
Surrogate Status	acting as surrogate	Being sponsored by a superpower in a conflict.
	acting with surrogate	Acting with a superpower-sponsored entity.

[a]Terms above the horizontal line are treated as ROSIE nouns; those below the line are treated as ROSIE adjectives.

not an adjective. In English, "cobelligerent" can be used as either a noun or an adjective. Both ROSIE and English syntax permit phrases such as "Belgium is a NATO cobelligerent combatant," but the Scenario Agent semantics do not. The reason is that ROSIE would parse "NATO" correctly as an adjective, "combatant" correctly as a noun, but "cobelligerent" incorrectly as an adjective. Scenario Agent semantics require two phrases in this case--"Belgium is a NATO cobelligerent" and "Belgium is a combatant."[3]

Table 2 is a complete list of the nouns and adjectives Scenario Agent uses to "speak of" entities.[4]

Military Situations

Scenario Agent needs to know the current military situation in order to simulate entity responses to that situation. Information about the military situation is provided by Force Operations as the so-called "force-data." Force Operations provides some of the same information to Red as the so-called "truth-table." The terms used to describe the military situation for Scenario Agent were therefore constrained by the capabilities of Force Operations and by the requirements of Red.

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[3] Alternatively, the phrase could be expressed as "Belgium is a cobelligerent" and "Belgium is a NATO combatant" or as "Belgium is a NATO cobelligerent that is a combatant."

[4] A similar description of the verbs Scenario Agent can use is beyond the scope of this Note. ROSIE recognizes "is" and "was" as forms of the verb "to be." ROSIE also recognizes "does" and "did" as auxiliary verbs, so that whatever immediately follows "does" or "did" in a sentence is taken to be a verb. ROSIE does not permit "France sends a message" because it can't parse "sends" correctly as a verb; it does parse "France does send a message" correctly because "does" identifies "send" as a verb. ROSIE has no concept of adverbs.

A military situation has many aspects, such as the parties involved in combat, the locations of conflict, the weapon types being used, and the projected combat outcome. Scenario Agent uses particular ROSIE terms to identify the different aspects of a military situation. The aspect types, terms that identify aspects, and terms for describing aspects are shown in Table 3. For aspects other than parties involved and locations of conflict, the choices of aspect description are mutually exclusive. That is, the red strategic weapon's type, for example, can be nuclear, conventional, or none--but not both nuclear and conventional.

As with the entity descriptors, force-data change over the course of an exercise. At any given game-point[5] they represent the then-current situation relevant to world political and military behavior.

Table 3 embodies two special ROSIE conventions that are noteworthy. One is the "=" and the other is the use of quotation marks. Because English uses "is" in ways that would be non-unique and ambiguous to a computer, ROSIE has two forms of "is." One type of "is" allows multiple predicate adjectives simultaneously; this is expressed in ROSIE as in "if England is a moderate combatant and England is a blue location of conflict." There is also a type of "is" that implies that something that is this, is not that. When we say something is big, we are also denying it is small. ROSIE uses "=" for that type of "is," as in "the red strategic weapon's type = nuclear." Values are assigned to the first type by means of such ROSIE statements as "assert England is a

[5] The game-point is a unique identifier used to synchronize the data bases of all the RSAC agents. Game-point is determined by Systems Monitor.

Table 3

TERMS USED TO DESCRIBE THE MILITARY SITUATION

Aspect Type	Terms that Identify Aspect	Terms that Describe Aspect
Parties Involved	(entity) is a combatant	(the name of any entity)
Locations of Conflict	(place) is a location of conflict	(the name of any entity), red-sea, blue-sea, or blue-space
Weapon Types in Use	the red strategic weapon's type = the blue strategic weapon's type = the red theater weapon's type = the blue theater weapon's type = the red local weapon's type = the blue local weapon's type = the white local weapon's type =	nuclear, cbr, conventional, or none
Projected Combat Outcome	the theater combat's prospect = the local combat's prospect =	"red win within 1 day", "red win within 30 days", "red win within 60 days", "blue win within 1 day", "blue win within 30 days", "blue win within 60 days", "white win within 1 day", "white win within 30 days", "white win within 60 days", or "indeterminate"
Superpower Involvement in Local Combat	red's involvement in local combat = blue's involvement in local combat =	offensive combat forces, defensive combat forces, surrogate sponsor, arms transfer, or none

Local Targeting	red's targeting in local combat =	civilian population, industry, military no civilian avoidance, military civilian avoidance, or none
	blue's targeting in local combat =	
	white's targeting in local combat =	
Superpower Non-combat Operations in Support of Local Conflict	a red intervention force is	deploying, deployed, withdrawing, en route, or terminating
	a blue intervention force is	
	a red surrogate force is	
	a blue surrogate force is	
	a red naval task force is	
	a blue naval task force is	
	a red arms transfer is	
	a blue arms transfer is	
Superpower Intelligence Capabilities	the quality of red intelligence =	high, medium, or low
	the quality of blue intelligence =	

location of conflict," which makes England a member of the class "location of conflict" without denying that England is a member of any class she already belongs to. Values are assigned to the second type by means of ROSIE statements like "let the quality of red intelligence be low." That type of assignment automatically cancels any other value that had been associated with the quality of red intelligence.

The permitted values for combat prospects are in quotation marks. This convention is a concession to ROSIE and a convenience to the Scenario Agent designers. The descriptive terms could be rephrased to a

ROSIE-acceptable form without the quotation marks, but the Red Agent program expects to see only the terms shown, rather than as something else, such as "red win within 17 days." Expressing these values as strings, in quotation marks, helps ensure that values incompatible with Red do not accidentally enter the Scenario Agent data base. It is important to regard these values as indicators of the gravity of the situation rather than as precise renderings of the actual prospects.

Messages

One of the Systems Monitor functions is to provide a means for Red, Blue, and Scenario to communicate with one another. International communications are modeled as stylized messages; the messages are transmitted over a general-purpose computerized message handling system.[6]

Incoming messages serve Scenario entities as proxies for the total spectrum of information sources they use as bases for inferring Red and Blue intentions. Scenario Agent processes incoming messages and generates appropriate responses. Such responses may be immediate or delayed entity status changes or may be messages to Red or Blue. Scenario entities cannot communicate with one another.[7]

Message conventions are shown in Table 4. Messages are formed by stringing together attribute values in the sequence the attributes are listed. For example, Blue may send this message to the FRG: "request change you combatant." FRG might reply "intend no change." The style,

[6] The message handling system is described in Borden, Gaines, and Shapiro (1979).

[7] Communication among Scenario entities will be addressed in a subsequent generation of the Agent.

Table 4

MESSAGE COMPONENTS

Message Attributes	Permitted Values
Time	(hour)/(day)(month)(year)
Reader (if message is to be forwarded)	red or blue
Sender	red, blue, or (any entity)
Receiver	red, blue, or (any entity)
Tone	(a1) demand (a2) suggest (a3) request (a4) agree (a5) intend (a6) refuse
Intent	(b1) change me (b2) remain (b3) no change (b4) change you
Color	(c1) red (c2) white (c3) blue
Alliance	(d1) nato (d2) wp
Tripwire	(e1) r-tripwired (e2) b-tripwired
Political status	(f1) cobelligerent (f2) coordinate

	(f3)	noncoordinate
Conflict arena	(g1)	local
	(g2)	theater
Military status	(h1)	combatant
	(h2)	combatant on call
	(h3)	noncombatant
Surrogate status	(i1)	acting as surrogate
	(i2)	acting with surrogate

though stilted, is understandable by man and machine. It is adequate for high-level international communication on military matters, but less well suited for diplomatic communication.[8] It does not, for instance, allow Blue to respond to FRG's reply with a "let's get together and talk about this" message. The available vocabulary is centered on conflict, and its limited nature discourages excessive reliance on messages, as opposed to manipulating forces, in constructing a move.

There are two equivalent stylistic conventions of messages; both are shown in Table 4. What has been described thus far is called the "terse" form. The entries in parentheses to the left of attribute values in Table 4 constitute the "terse-terse" form. The terse-terse identifiers were designed to increase speed and reliability in composing, transmitting, and processing messages. Terse-terse reduces the chances for errors due to misspelling or improper ordering of message attributes.

[8] Adequacy of the message conventions for substantive strategic analysis will be assessed in Phase II.

SCENARIO AGENT OPERATING SYSTEM

Scenario Agent operations include input, processing, and output, as shown in Fig. 2.

Inputs

There are three inputs to Scenario Agent: the military situation, messages to Scenario entities, and the game-step and game-time, which are generated by Force Operations, Red/Blue, and Systems Monitor, respectively. Although the exact format of these inputs is not important to the current discussion, the content of the inputs is summarized in Tables 3 and 4.

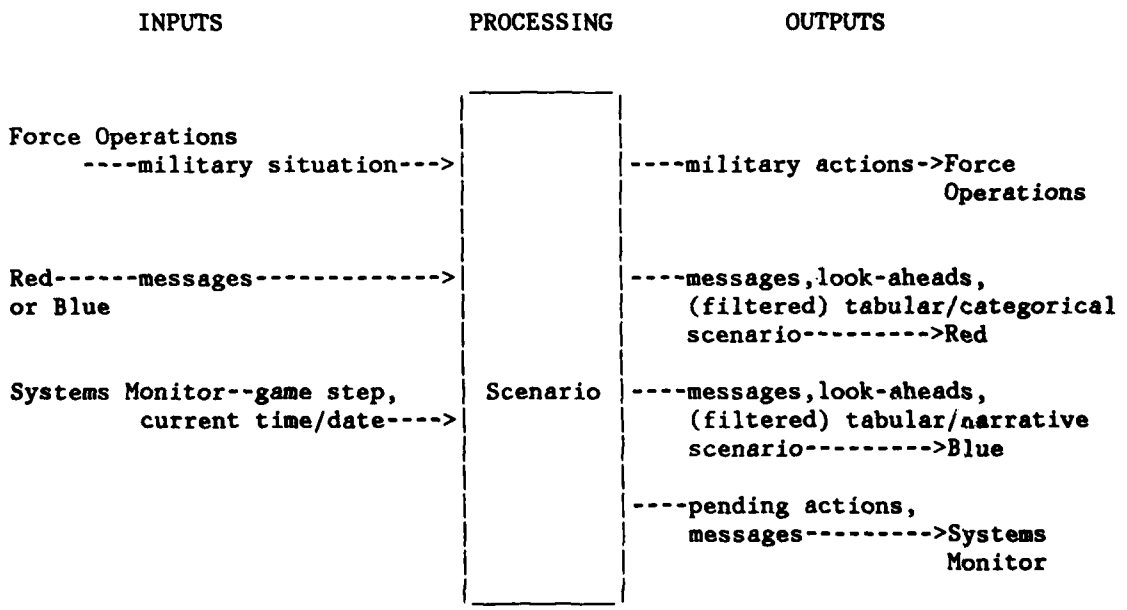

Fig. 2--Scenario Agent operations

Processing

The "intelligence" of the Scenario Agent is captured in the form of rules. Those rules are of the form: "if (conditions), then (actions)." That is, "if the following conditions are met, then take the following actions." In general the conditions that Scenario Agent checks against are subsets of the military situation and the message traffic. Whenever a new military situation or a new set of messages is presented to Scenario Agent, it runs through all of its rules to see if any of the conditions are met, and for each rule whose conditions are met it takes the appropriate actions.

Caveat: Although Scenario Agent rules embody ideas from several members of the RSAC staff about how entities might act under various conditions, we do not claim that the rules express facts. Nor do we claim that the rules express a definitive consensus of professional scholarly judgment. Rules can and should be varied--in an attempt to bound plausible international behavior by using alternative rule sets. The Scenario Agent operating system was designed to accommodate alternative rule sets, though only one of many plausible alternatives was developed during Phase I. We plan to develop more sophisticated alternatives in Phase II.

Scenario Agent rules are of two types: "Message rules" handle all cases in which messages are present, and "situation rules" handle those cases in which messages are not present. The reason for the distinction is that nations are sensitive to messages from Red or Blue and are likely to behave differently in their presence than in their absence. Separating the rules into distinct sets allows them to be processed in

sequence with messages rules taking precedence. That is, if a Scenario entity has a message from Red or Blue the actions it would take as a function of that message and the situation take precedence over the actions it would have taken based on the situation alone.

Message Rules. Messages from a superpower to its allies are generally agreed to if the superpower is winning, but are generally ignored if the superpower is losing. Responses to messages from a superpower to its opponents are based on additional considerations, including the tone of the message and the resolve of the message receiver.

The majority of Scenario entity responses to messages can be explained in two tables--one explains the actions by the receiver if the sender is of the same color and the other the case when the sender is not of the same color.

For the case when the sender and receiver are of the same color, the responses are summarized in Table 5. Firm entities agree no matter

Table 5

ENTITY RESPONSES TO MESSAGES FROM SAME COLOR SENDER

		Message Tone		
		Request	Suggest	Demand
Resolve of Receiver	Firm	AGREE	AGREE	AGREE
	Moderate	IGNORE	AGREE/ IGNORE	AGREE/ IGNORE
	Soft	IGNORE	IGNORE	AGREE/ IGNORE

what the tone of the message. Moderate and soft entities agree only to certain message tones, and then they agree only if the combat prospects of the sender are "indeterminate" or better.

If the sender and receiver are not of the same color, the message responses are as summarized in Table 6. In this case the tone is ignored and the sender's combat prospects are heeded. Again, the better the sender is doing, the more amenable the receiver will be.

Although these fixed responses are quite crude, they exhibit nominal behavior that has not been distracting in the system exercises to date. More sophisticated rules are under development.

Situation Rules. The centerpiece of the RSAC Phase I effort was the interaction of Red and Blue forces, not only with each other, but with the forces of other entities. Because this basic Red-Blue force interaction would be influenced by the conduct of NATO and Warsaw Pact allies, we saw the most important and demanding portion of the situation

Table 6

ENTITY RESPONSES TO MESSAGES FROM DIFFERENT COLOR SENDER

		Sender's Combat Prospects			
		Indeterminate or Loss	Win Within 60 days	Win Within 30 days	Win Within 1 day
Resolve of Receiver	Firm	IGNORE	IGNORE	IGNORE	AGREE
	Moderate	IGNORE	IGNORE	AGREE	AGREE
	Soft	IGNORE	AGREE	AGREE	AGREE

rules to be those concerning how much these allies support or refuse to support Red and Blue. Blue's allies pose a special problem here: NATO's European members may be more independent of the United States than their Warsaw Pact counterparts are of the USSR and also more dependent on Persian Gulf oil. We tried to produce a set of rules that reflects one of many possible rational views of the military-operational consequences for Red and Blue of the politics of their alliances and associations worldwide.

The first-generation Scenario Agent operating system can process alternative rule sets, though only one illustrative rule set was developed in Phase I.

Our starting premise was that these alliance-superpower interactions are shaped first of all by the location in which conflict occurs. For conflicts in third areas besides the Middle East, Red and Blue allies are likely to sit back and watch (and possibly participate, as in the case of France in Africa), significantly changing neither political nor force commitments to Red or Blue. Conflicts in the Middle East have potentially profound implications for NATO's cohesiveness, a much less direct and drastic effect on Warsaw Pact ties. Finally, conflicts in Europe or between the superpowers themselves, of course, affect alliance entities, hence Red and Blue military operations, most directly. Thus, we wrote three sets of rules, dealing with conflicts involving (1) Blue-NATO/Red-WP, (2) Middle Eastern states, or (3) the rest of the world.

Our "rest of the world" rules are fairly simple. Client entities beginning to lose in a local conflict ask Red or Blue for aid. If client entities are losing badly, they ask Red or Blue for combat support. Local defeat for a Red or Blue coordinate slightly perturbs Red

or Blue affiliates and may even weaken one or the other's alliance structure, as will Red or Blue's use of nuclear weapons locally. Red's alliance and affiliate structure is slightly more resilient than Blue's--a reflection less of current U.S. trials and tribulations than of Red's location at the center of the Eurasian land-mass, adjacent to and militarily dominating its Warsaw Pact allies.

For conflicts in the Middle East (an area we define in the rules by referring to a specific set of entity names--Saudi Arabia, Israel, etc.), this basic set of rules is supplemented (not replaced) by a special set of rules governing European reactions to the flow of events. NATO will support Blue in its support of oil-producing states. A Blue loss in the region strongly perturbs the Alliance. Indeed, should certain combinations of Persian Gulf entities become Red coordinates or Red-tripwires (hosting invited or uninvited Soviet forces) whether as the result of combat or political pressure, NATO's European members' resolve as blue affiliates becomes soft, and they respond positively to Red's request (if it materializes) that they turn white. Warsaw Pact reaction to conflict in the Middle East is a product of the general rules set out for Red losses in the rest of the world.

For conflicts in NATO or Warsaw Pact nations, a set of control rules evokes one of two alternative rule sets governing NATO's behavior. One rule set governs the Pact. Concerning NATO, there is a strident NATO and a reluctant NATO. The behaviors of these differ in the six areas displayed in Table 7--reaction to theater nuclear detonations, commitment of conventional forces, and so forth. Basically, a strident NATO will fight alongside Blue to the end in most cases, becoming reluctant only when a strategic nuclear exchange seems likely to produce a

Red victory. France joins the conflict early, and thereafter supports the NATO objectives. The reluctant NATO won't agree to use theater nuclear weapons first, will constantly call for de-escalation, and, its collective eye always on prospective outcomes, will surrender (if asked) if it thinks Blue is going to lose. France will take the lead on these issues, agreeing to fight only if attacked.

Our assumption is that NATO at any time could be coherent or fragmented, strident or reluctant, depending mostly on how a theater conflict starts. If Western Europeans feel the United States is dragging them into a theater war, if they perceive a chance to contain conflict to one nation (most likely the FRG), or if the Soviets take steps to suggest, implicitly or explicitly, that they will leave most of Europe unmolested if Europe's other NATO members sit tight, these states may be quite reluctant to become involved in a widening war. If, however, the Soviets attack first on a wide front, Western Europe is likely to be unified by its common enemy and fight as an alliance.

Our rules try to capture these starting conditions in a set of rather simple input variables, namely (1) locations of conflict; (2) local, theater, and strategic weapons types; and (3) combat outcome prospects. We use the first two input variables to construct triggering conditions for invoking one or the other NATO rule set. Locations of conflict provide a measure of how big the war is when it starts, and weapon types in use give a measure of who goes first (which gives an even rougher measure of whether the Europeans are being dragged into a conflict or are responding to an attack). Table 8 is a matrix of starting conditions and the corresponding NATO rule sets evoked in each case.

Table 7

SUMMARY OF ALTERNATIVE NATO RULE SETS

	Strident NATO Response	Reluctant NATO Response
Willingness To Commit Conventional Forces	France will agree, if asked, to become a blue combatant on call and then will respond to Blue's instructions, as will other NATO entities	France will fight only when attacked (when France is a location of conflict). Other NATO entities will commit to a conventional war only, will send messages to Red and Blue calling for de-escalation.
Willingness To OK First Use of Nucs	Will agree to limited first use. If Blue overrides and uses TNF in major attack, "better red than dead" rules invoked---------->	Won't do it. If US overrides and launches TNF, will stay blue unless and until Red responds with TNW, then will become moderate white.
Willingness To Endure a Theater Nuc Exchange	Will remain committed to Blue until theater prospects = Red win within 1 day.	Will go soft blue. Will go white if requested by Red. Will go white in any case if TNW exchange lasts 2 days.
Willingness of UK, France To Use National Deterrents	Will use if either becomes a location of conflict and Red already is using TNW.	Will use only if Red has used nuclear forces on them, and if prospects = Blue win within 30 or 60 days.
Reaction to Strategic Nuclear Exchange	Will go soft blue. Will go moderate white if both strategic weapons = nuclear and prospects = Red win within 30 days or 1 day.	Will go soft blue. Will go white if requested by Red. Will go white in any case if strategic exchange lasts 2 days.
Reaction to Changing Combat Prospects	Will stay firm blue until Blue loses, unless overridden by reaction to strategic nuclear exchange (above).	If Red win is within 30 days or 1 day, will go soft blue, white if asked. Will go white anyway if prospects don't improve in 2 days.

Red's Warsaw Pact allies can also become reluctant, although only if Red begins to lose badly. Our rules thus attribute somewhat more cohesiveness to the Pact than to NATO.

Although our rules certainly miss many of the subtleties of international relations, they do provide a conceptual framework that generates sequential scenarios in assessment exercises and is easy to expand.

Outputs

Scenario Agent outputs are the military and political actions and status of all of the exercise-relevant entities of the world except for

Table 8

TRIGGERING CONDITIONS FOR NATO RULE SETS[a]

		First Move[b]			
		Red		Blue	
		Conventional	Nuclear	Conventional	Nuclear
Size of War[c]	1 NATO Entity	STRIDENT	RELUCTANT	RELUCTANT	RELUCTANT
	>1 NATO Entity	STRIDENT	STRIDENT	STRIDENT	RELUCTANT

[a]If no red or blue weapons are in use (that is, the conflict is strictly local, say, an inter-German conflict), NATO entities will become moderate--a hedge position--from which they can become reluctant or strident as events determine.

[b]Color of side whose theater weapons are used first.

[c]Number of NATO entities that are locations of conflict when either red or blue theater weapons are first used.

Red and Blue. The format varies depending on who receives the information. Force Operations receives only military action information (and the only actions available to Scenario entities are to fight or mobilize in coordination with a superpower or to stop fighting or mobilizing). In the demonstrations Red was automated so the outputs were formatted to the Red program's specifications. Scenario entities can also send messages in the form described in Table 4.

The primary form of the output, however, is the tableau. A truncated version of a tableau is shown in Table 9, and a complete example is shown in Appendix B.

The point to be emphasized here in connection with ROSIE is that the tableau is more than a listing of the current status of the entities of interest; it is also a reformatting of the internal descriptors that ROSIE carries for those entities. ROSIE "thinks" of the entities in the same manner that it "talks" about them to the outside world. This is the major reason why ROSIE is such a comfortable language in which to

Table 9

EXAMPLE OF TABULAR SCENARIO (TABLEAU)

AUSTRIA					
mod	white		noncoord	noncombatant	
BELGIUM					
firm	blue	nato b	cobellig theater	noncombatant	
FRG					
firm	blue	nato	cobellig theater	combatant	location
GDR					
firm	red	wp	cobellig theater	combatant	location

program an agent that must be transparent to various observers and contributors.

A separate ROSIE program uses the Scenario data base to prepare a narrative intelligence report for Red or Blue human teams. Table 10 is the part of a narrative report based on the same information that was summarized in Table 9. The narrative report contains information based on force data, such as weapon use and outcome prospects, which do not appear in the tableau. An complete example of the narrative report is provided in Appendix C.

Table 10

EXAMPLE OF NARRATIVE SCENARIO

Locations of Conflict

Combat operations are or were being conducted in or against the following location(s):

FRG
GDR

Combatants

The following are engaged in combat in coordination with the combatant forces of the Soviet Union and/or its allies. They are strongly committed to this position and are not likely to make a major change.

GDR

The following are engaged in combat in coordination with the combatant forces of the United States and/or its allies. They are strongly committed to this position and are not likely to make a major change.

FRG

Theater Outcome Prospect

The expected outcome of theater combat, assuming no changes in either side's targeting, is red win within 60 days.

Noncombatants

American combat capable forces are deployed on bases in the following territory. A hostile attack on that territory would involve those U.S. forces and, therefore, the United States in the conflict.

BELGIUM

The following do not share any superpower's preferences for outcome of any ongoing combat, are not involved in combat, and are not providing any significant military assistance to any combatant. They might possibly change their position to suit future conditions.

AUSTRIA

V. STATUS OF SCENARIO AGENT DEVELOPMENT

The first-generation RSAC was demonstrated to government observers in January 1981. The Scenario Agent performed its functions--with only one exception--to everyone's satisfaction. The exception is notable.

During the last day of the demonstrations a situation arose that had not been reached in any previous exercises and the Scenario changed the Soviet Union to a status that an observing evaluator found objectionable. The Scenario operator agreed and on the spot: (1) called up the responsible rule, (2) changed the rule to their mutual satisfaction, (3) reran the Scenario move, and (4) checked to make sure the result was consistent with the altered rule. All of this happened without the notice of the rest of the system and left the observer both satisfied with the result and impressed with the Scenario's capabilities.

Though the Scenario met the Phase I design goals, experience has revealed several limitations in the first-generation design. We shall mention four such limitations here. First, Scenario is limited in tracking more than one conflict at a time. All local combatants are assumed to be fighting in the same conflict. A conflict that escalates from local to theater level ceases to be simulated as a local conflict. This would not be satisfactory for modeling situations in which local combatants continue to respond to the local situation, even after the conflict escalates. Second, the existing theater conflict rules were written with the European theater in mind. The rules would be much less appropriate for conflict in other theaters. The "oil rules" that relate

European entities' behavior to the status of Persian Gulf oil producers need improvement. Third, entities have no tactical control over their own forces. Entities are limited to declaring themselves combatants or noncombatants. If they become cobelligerent combatants, their forces are controlled by the superpower with which they are affiliated. Fourth, non-superpower entities cannot communicate with one another. Scenario entities can send messages only to Red or Blue. These limitations are not conceptually difficult to overcome.

The Scenario Agent uses the ROSIE language, which was designed for artificial intelligence applications. Several recent advances in artificial intelligence that were not used in the first-generation Scenario might be useful for subsequent generations. Some of these possibilities are discussed in Appendix D, which begins with a brief introduction to rule-based modeling.

Phase II research is using the RSAC for analysis of a force structure issue of strategic interest. The Scenario Agent's rule base will be improved, as needed, to support that analysis. Improvements will include development of more nation-specific rules, explicit recognition of superpower intentions, better treatment of uncertainties, and incorporation of more subtlety into the rules. The basic design, as described in this Note, will not be changed in Phase II, but capability to determine the reasons for entity actions, by tracing backward through the rule structure, will be improved. Scenario Agent design alternatives will be discussed in a forthcoming Note. Phase II will be completed in 1982.

Appendix A

NAMES OF SCENARIO ENTITIES

Afghanistan
Albania
Algeria
Angola
Argentina
Australia
Austria
Bangladesh
Belgium
Bolivia
Botswana
Brazil
Bulgaria
Burma
Cambodia
Cameroon
Canada
Central.African.Rep
Chad
Chile
Colombia
Congo
Costa.Rica
Cuba.Havana
Czechoslovakia
Dahomey
Denmark
Dominican.Rep
Egypt
El.Salvador
Equador
Ethiopia
FRG
Finland
France
Gabon
Gambia
GDR
Ghana
Greece
Guatemala
Guinea
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Ivory.Coast
Jamaica
Japan
Kenya
Kuwait
Laos
Lebanon
Liberia
Libya
Luxemburg
Madagascar
Malaysia
Mali
Mauritania
Mexico
Mongolia
Morocco
Mozambique
N.Yemen
Netherlands
New.Zealand
Nicaragua
Nigeria
N.Korea
Norway
Oman
Panama
Paraguay
Peru
Philippines
Poland
Portugal
PRC
Romania
S.Yemen
Sarawak
Saudi.Arabia
Senegal
Singapore
Sierra.Leone
Somalia
S.Africa
S.Korea
SW.Africa
Spain
Sudan
Surinam
Sweden
Switzerland
Taiwan
Thailand
Togo
Turkey
Uganda
UK
United.Arab.Emirates
Upper.Volta
Uruguay
Venezuela
Vietnam
Yugoslavia
Zaire
Zambia
Zimbabwe

Appendix B

EXAMPLE OF TABULAR SCENARIO (TABLEAU)[a]

```
AUSTRIA
 mod   white          noncoord          noncombatant

BELGIUM
 firm  blue  nato     cobellig theater  combatant              location

BULGARIA
 firm  red   wp       cobellig theater  combatant

CANADA
 firm  blue  nato b   cobellig theater  combatant

CZECHOSLOVAKIA
 firm  red   wp       cobellig theater  combatant              location

DENMARK
 firm  blue  nato     cobellig theater  combatant              location

FRG
 firm  blue  nato     cobellig theater  combatant              location

FRANCE
 firm  blue           cobellig theater  combatant              location

GDR
 firm  red   wp       cobellig theater  combatant              location

GREECE
 firm  blue  nato b   coord    theater  comb on call

HUNGARY
 firm  red   wp    r  cobellig theater  combatant

ICELAND
 firm  blue  nato b   coord    theater  comb on call

ITALY
 firm  blue  nato b   coord    theater  comb on call

LUXEMBURG
 firm  blue  nato     coord    theater  comb on call
```

NETHERLANDS						
firm	blue	nato	cobellig	theater	combatant	location
NORWAY						
firm	blue	nato	coord	theater	comb on call	
POLAND						
firm	red	wp	cobellig	theater	combatant	location
PORTUGAL						
firm	blue	nato b	coord	theater	comb on call	
ROMANIA						
firm	red	wp	cobellig	theater	combatant	
SU						
firm	red	wp	bellig	theater	combatant	
SPAIN						
firm	blue	b	coord	theater	comb on call	
TURKEY						
firm	blue	nato b	coord	theater	comb on call	
UK						
firm	blue	nato	cobellig	theater	combatant	location
US						
firm	blue	nato	bellig	theater	combatant	
YUGOSLAVIA						
mod	white		noncoord		noncombatant	

[a]The following abbreviations were necessary to fit tableaus on standard size paper:

mod	moderate
b	b-tripwired
r	r-tripwired
bellig	belligerent
cobellig	cobelligerent
coord	coordinate
noncoord	noncoordinate
comb on call	combatan on call
location	location of conflict

Appendix C

EXAMPLE OF NARRATIVE SCENARIO[a]

Locations of Conflict

Combat operations are or were being conducted in or against the following location(s):

BELGIUM
CZECHOSLOVAKIA
DENMARK
FRG
FRANCE
GDR
NETHERLANDS
POLAND
UK

Soviet surface vessels, submarines, or aircraft located outside of Soviet territorial waters are being brought under attack.

United States surface vessels, submarines, or aircraft located outside of U.S. territorial waters are being brought under attack.

Combatants

The following are engaged in combat in coordination with the combatant forces of the Soviet Union and/or its allies. They are strongly committed to this position and are not likely to make a major change.

GDR
POLAND
CZECHOSLOVAKIA
BULGARIA
HUNGARY
ROMANIA

The following are engaged in combat in coordination with the combatant forces of the United States and/or its allies. They are strongly committed to this position and are not likely to make a major change.

FRG
DENMARK
NETHERLANDS
BELGIUM
UK
FRANCE
CANADA

Weapon Use

Blue is using strategic conventional weapons while Red is not using any strategic weapons.

Both Red and Blue are using theater conventional weapons.

Theater Outcome Prospect

The expected outcome of theater combat, assuming no changes in either side's targeting, is red win within 60 days.

Noncombatants

The following have agreed to coordinate their force commitments with those of the United States if a theater combat contingency develops.

GREECE
ICELAND
ITALY
LUXEMBURG
NORWAY
PORTUGAL
TURKEY
SPAIN

Soviet combat capable forces are deployed on bases in the following territory. A hostile attack on that territory would involve those Soviet forces and, therefore, the Soviet Union in the conflict.

HUNGARY

American combat capable forces are deployed on bases in the following territory. A hostile attack on that territory would involve those U.S. forces and, therefore, the United States in the conflict.

CANADA
GREECE
ICELAND
ITALY
PORTUGAL
SPAIN
TURKEY

The following do not share any superpower's preferences for outcome of any ongoing combat, are not involved in combat, and are not providing any significant military assistance to any combatant. They might possibly change their position to suit future conditions.

AUSTRIA
YUGOSLAVIA

Intelligence

The quality of red intelligence is HIGH. The quality of blue intelligence is HIGH.

[a]This is identical in content to the information in Appendix B, having been prepared from the same Scenario data base.

Appendix D

RULE-BASED MODELING

Rule-based modeling is an area of artificial intelligence that has been applied at Rand and elsewhere to problems in chemistry,[1] medicine,[2] pollution control[3], legal reasoning,[4] and anti-terrorism.[5]

Rule-based models have been found useful in knowledge engineering--that is, in capturing experts' knowledge within the models. An English-like language, called ROSIE, has been developed at Rand for building rule-based models. The term "English-like" means roughly that code written in the language can be understood by people who know English but not necessarily any computer language. For example, the following sentence is an executable ROSIE statement: "if England is a noncombatant and there is a NATO combatant that is a location of conflict, assert England will be a combatant within 30 days."[6]

QUALITATIVE CERTAINTY

It has been argued[7] that rules with conjunctive phrases (connected by "and") in their left hand (condition) side contain certainty

---

[1] The DENDRAL program, developed by Feigenbaum and Lederberg at Stanford University, is described in Raphael (1976).

[2] Shortliffe (1976).

[3] F. Hayes-Roth et al. (1981).

[4] Waterman and Peterson (1981).

[5] Waterman and Jenkins (1977).

[6] Additional information on knowledge engineering can be found in Mostow and Hayes-Roth (1979); on designing "expert systems" in Callero et al. (1981); and on production systems in Waterman (1970) and (1976).

[7] Davis (1975).

value equal to the minimum of the certainty values associated with the phrases. For example, if the rule is

if x and y, then z

and x is "certain" and y is "likely," then z is "likely." However, rules with disjunctive phrases (connected by "or") in the left hand side contain information of value equal to the maximum of the certainty values associated with the phrases. Thus, if x is "certain" and y is "likely," we would infer from

if x or y, then z

that z is "certain."

AGENTS THAT LEARN

The initial version "learns" when someone uses an editor to change the rules. It may be desirable to operate Scenario in a learning mode--that is, in a mode in which Scenario changes its rules based on what it "learns" from RSAC exercises as they are played. The MYCIN program[8] is an example of a program that formulates changes to its rules and presents them to the operator for approval or reformulation.[9]

SHORT TERM IMAGES

As more expert knowledge is put into a rule base, the rule base generally becomes larger and more complex. Managing execution of the rule base--determining which rules first to test--becomes a problem. Outcomes often depend on the sequence of testing. One heuristic for

[8] Shortliffe (1976).

[9] Techniques for automating the learning of heuristics are discussed in Waterman (1976).

dealing with this is first to test those rules whose conditions were met in recent prior tests. Sylvan and others have applied the following such heuristic in the context of foreign policy decisionmaking.

> 1. The [rules] are considered in sequence, starting with the first.
>
> 2. Each condition is compared with the current state of knowledge in the system, as represented by data in a short term image (STI) data base. If all of the elements in a condition can be matched with elements (in any order) in the STI, then the condition is satisfied. The STI is a stack in which a new element appears at the top, pushing all else in the stack down one position. Since the STI is limited in size, elements may be lost.
>
> 3. If a condition is not satisfied, the next . . . rule in the ordered list of . . . rules is considered.
>
> 4. If a condition is satisfied, the right hand side actions are taken. Then the [rule] system is reentered from the top (step 1).
>
> 5. If a condition is satisfied, all those STI elements that were matched are moved to the front of the STI.
>
> 6. Actions can change the state of goals, replace elements, apply operators, or add elements to the STI.[10]

GOALS, PLANNING, AND COUNTERPLANNING

Scenario entities do not pursue goals, nor do they plan. They simply respond. That will suffice for some applications, but might not for others. Carbonell developed goal-directed heuristics for the POLITICS model that might be relevant to Scenario.

> General strategies for an actor A preventing actor X from achieving its goal G(X):

---

[10] Sylvan et al. (1977).

1. Discover what plan X is pursuing in order to achieve G(X). This is a matter of inference; A's perception of X may be dependent on A's ideology.

2. Failing (1), decide what plan A would use if it was in X's situation. Expect X to pursue such a plan.

3. Discover the weakest, most easily blocked link in the plan.

4. Apply one of the counterplanning rules (listed below) to block the plan at its weakest link.

5. Expect X to modify his plan to bypass the blocked link or to formulate a new plan.

6. Block the new or modified plan.

7. If G(X) is very high priority, then expect X to pursue more than one plan simultaneously to achieve G(X). Block all plans.

8. If at any point the cost of blocking G(X) exceeds the cost associated with X achieving G(X), abandon the counterplanning.

General strategies for an actor A to achieve its goal G(A) in spite of active intentional interference from X:

1. Apply normal planning strategy to find a plan to achieve G(A).

2. If X blocks the plan, find an alternative plan or:

   a Bypass the blocked link (by modifying A's plan).

   b. Block some goal X is trying to achieve, and bargain to mutually stop blocking each other's plans.

   c. (Temporarily) abandon G(A) until X is no longer blocking a vital link.

3. If G(A) is of high importance to A, pursue multiple plans simultaneously to achieve G(A).

4. If G(A) is a subgoal to a higher level goal G'(A), find a new plan for G'(A) which does not require achieving G(A).

5. If X needs to achieve some G(X) in order to block a link in A's plan for G(A), then simultaneously block X's plan to G(X) while pursuing G(A).

There are six counterplanning rules:

C1. To stop actor X from accomplishing G(X), see if there is any goal G(A) which is mutually exclusive with G(X). If so, give high priority to accomplishing G(A).

C2. If A wishes to accomplish G(A) and G(A) is being blocked by X working on a mutually exclusive G(X), try to thwart G(X) by some other *means*.

C3. To prevent X from achieving G(X), threaten a higher level goal of X, say G'(X). Thus, expect X to divert its efforts to G'(X).

C4. To prevent X from achieving G(X), prevent X from achieving a necessary subgoal of G(X).

C5. To achieve G(A) if X is blocking a subgoal of G(A), try to find an alternative plan for G(A).

C6. If G(A) and G(X) are in conflict and there exists G'(A) = G'(X) where the G' goals are not lower level than the G goals, then A should try mediating with X to mutually achieve G' and abandon their respective G goals.[11]

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[11] Carbonell (1978).

BIBLIOGRAPHY

Borden, B. S., R. S. Gaines, and N. Z. Shapiro, The MH Message Handling System: User's Manual, The Rand Corporation, R-2367-AF, Santa Monica, November 1979.

Callero, M., et al., Toward an Expert Aid for Tactical Air Targeting, The Rand Corporation, N-1645-ARPA, Santa Monica, January 1981.

Carbonell, J. G., Jr., "POLITICS: Automated Ideological Reasoning," Cognitive Science, 2, 27-51 (1978).

Davis, R., et al., Production Rules as a Representation for a Knowledge-Based Consultation Program, Stanford Artificial Intelligence Laboratory, Memo AIM-266, October 1975.

Fain, J., et al., The ROSIE Language Reference Manual, The Rand Corporation, N-1647-ARPA, Santa Monica, December 1981.

Graubard, M. H., and C. H. Builder, Rand's Strategic Assessment Center: An Overview of the Concept, The Rand Corporation, N-1583-DNA, Santa Monica, September 1980.

Hayes-Roth R., et al., Rationale and Motivation for ROSIE, The Rand Corporation, N-1648-ARPA, Santa Monica, November 1981.

Mostow, J., and F. Hayes-Roth, Machine-Aided Heuristic Programming: A Paradigm for Knowledge Engineering, The Rand Corporation, N-1007-NSF, Santa Monica, February 1979.

Raphael, Bertram, The Thinking Computer, W. H. Freeman and Company, New York, 1976.

Shortliffe, E. H., Computer-Based Medical Consultations: MYCIN, American Elsevier Publishing Company, Inc., New York, 1976.

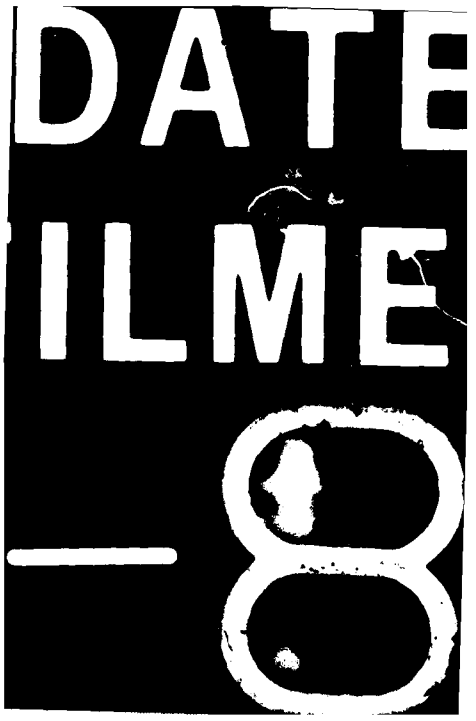
Sylvan, D. A., et al., "Processing Styles and Theories of Foreign Policy Decision Making," unpublished paper delivered at the 1977 annual meeting of the International Studies Association, St. Louis, March 16-20, 1977.

Waterman, D. A., "Generalization Learning Techniques for Automating the Learning of Heuristics," Artificial Intelligence, Vol. 1, pp. 121-170, 1970.

Waterman, D. A., An Introduction to Production Systems, The Rand Corporation, P-5751, Santa Monica, November 1976.

Waterman, D. A., and B. Jenkins, Heuristic Modeling Using Rule-Based Computer Systems, The Rand Corporation, P-5811, Santa Monica, March 1977.

Waterman, D. A., and M. Peterson, Models of Legal Decisionmaking, The Rand Corporation, R-2717-ICJ, Santa Monica, 1981.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